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THE UNIVERSITY OF TORONTO AND THE MINERAL INDUSTRY

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(Part II.)

Mineralogy is the science of minerals, and geology is the science of rocks. The basis of the mineral industry is minerals, and minerals are found in rocks. Hence, to the popular mind the syllogism is complete; the shortest step is to go to geology and mineralogy for that enlightenment and for that philosophy which will aid the mineral industry. Thus the two handmaidens of the profession of mining engineering are mistaken for the mistress.

In 1856, Dr. E. J. Chapman was appointed Professor of Mineralogy and Geology in the University of Toronto and, at that time, the University stamped its approval of the teaching of mineralogy and geology in advanced education.

The first curriculum of the S. P. S., published in the prospectus of the first session, 1878-79, was as follows:—

(1) Department of Engineering

This course is intended to qualify students to prosecute the various professional branches of engineering. During the first two years the course is for the most part common to the students of all three branches (Civil, Mechanical and Mining Engineering). In the course of the second year, however, the student is required to select such one of the three branches which he intends to specially pursue, and the studies of the third year are arranged in conformity therewith.

Subjects of the First Year

1. Mathematics—including Plane Trigonometry and Analytical Conic Sections.
2. Mechanics—Elementary Statics and Calculations of Framed Structures.
3. Drawing—Freehand, Linear and Elementary Projection.
4. Surveying—Chain and Compass. Plotting from Notes.
5. Construction—General Principles and Foundations.
6. Elementary Chemistry.

Subjects of the Second Year

A.—Common to all Three Branches.

1. Mathematics—Differential and Integral Calculi and Spherical Trigonometry.
2. Drawing—Freehand and Descriptive Geometry.
3. Physics—Statics and Dynamics, Hydraulics and Optics.
4. Mensuration.
5. Elementary Mineralogy and Geology.

B.—Special Subjects for each Branch.

Civil—
- Geodesy and Astronomy.
- Surveying—Theodolite, Level, etc.
- Construction—Roads and Railways.

Mechanical—
- Machinery.
- Designing.

Mining—
- Crystallography.
- Palaeontology.
- Determinative Mineralogy.
- Blowpipe Analysis.
- Surveying.

Subjects of the Third Year

Civil—
- Surveying—Railway and Canal Surveying, Hydrography.
- Freehand Drawing.
- Applied Mechanics—Resistance of Material Structures in Stone, Wood and Iron.
- Hydraulics—Water Supply, Drainage.
- Mineralogy—Determination of Minerals. Minerals of Ontario.
- Metallurgy—Manufacture of Iron and Steel.
- Construction—Bridges, Canals and Harbours.
- Steam Engines.
- Experimental Physics.
- Designing and Estimates.

Mechanical—
- Physics—Mechanical Theory of Heat

Freehand Drawing.
Applied Mechanics—Resistance of Materials. Structures in Stone, Wood and Iron.
Machines—Proportions and Parts.
Motors—Steam and Hydraulic Engines, and Pumping Machinery.
Mineralogy—Determination of Minerals. Minerals of Ontario.
Metallurgy—Manufacture of Iron and Steel.
Experimental Physics.
Designing and Estimates.

Mining—

Assaying and Ore-dressing.
Crystallography, Geology and Palaeontology.
Mining—Geology.
Mining Processes Employed.
Mining Machinery.
Motors—Steam and Hydraulic Engines, and Pumping Machinery.
Metallurgy.
Chemistry.
Experimental Physics.

From this it will be seen that Elementary Mineralogy and Geology took their places in all branches of engineering in the first year and the Determination of Minerals and the Minerals of Ontario in the third year.

In addition to the course in Mining Engineering there was a department apparently closer to the Mineral industry.

(2) Department of Assaying and Mining Geology

In this department the student is fully prepared in all the methods of analysis necessary to render him a competent assayist. He is also qualified to survey and report upon the value of mineral lands.

Subjects of First Year

1. Elementary Mathematics, including Mensuration and Plane Trigonometry.
2. Elements of Natural Philosophy, including Mechanics, Hydraulics.
3. Inorganic Chemistry.
4. Elementary Biology.
5. Elementary Mineralogy and Blowpipe Practice.
6. Physical Geography, Palaeontology and Geology.
7. Drawing.

Subjects of Second Year

1. Higher Mathematics, including Spherical Trigonometry, etc.
2. Chemistry, with laboratory practice in Qualitative Analysis.
3. Blowpipe Analysis and Determinative Mineralogy.

4. Geology and Economic Minerals of Canada.
5. Surveying and Levelling.

Subjects of Third Year

1. Quantitative Chemical Analysis.
2. Metallurgy.
3. Assaying.
4. Study of Metallic Veins and other Mineral Deposits, Mining Calculations, Examination of Mineral Lands.

It is to be noted that, after this course, the graduate was alleged to be qualified to report on the value of mineral lands, a fallacy from which we are now trying to escape.

This curriculum in Assaying and Mining Geology remained practically without change until it was abandoned in 1892. In fact the only change that was made appears to have been in the substitution of the word "assayer" for "assayist" in 1882. I can find no record of any student having graduated in this course.

In 1892, Mining Engineering, which for several years had been included as a sub-division of the Department of Civil Engineering, appeared as a separate department. The work of this new department differed from the course in Civil Engineering chiefly in the addition of more Chemistry, Mineralogy and Geology, together with some Mining Metallurgy, Ore-dressing and Assaying. Drawing and some other subjects were squeezed, and Hydrographic-survey and Drainage, Sewerage, etc., were dropped to make room for the mining subjects. At this time, also, was instituted an additional and optional fourth year leading to the degree of B.A.Sc. which has been referred to in Part I of this series. For the students in Mining Engineering the subjects of study in the fourth year were Mineralogy, Geology, Metallurgy and Assaying. In connection with that it is interesting to note that there was at this time no professor or lecturer in mining, but there was a professor in Mineralogy and Geology, and a professor of Metallurgy and Assaying, the latter of whom became professor of Geology at a later date. In regard to the details of the curriculum and the amount of time devoted to the different subjects, the Calendars are not explicit or specific until a later date; but, apparently this curriculum remained much the same for many years, there being from time to time, some increases in the work in Mineralogy, Geology and Chemistry.

It is of importance to note that in the third year curriculum under the heading of Mineralogy and Geology the sub-divisions are, Economic Geology, Palaeontology, Blowpipe Analysis, and Determinative Mineralogy, *Metallurgy, Mining, Ore-Dressing, Assaying* (the italics are mine); and these four last subjects remained classified in the calendars under the heading of Mineralogy and Geology for ten years or more. As further evidence of the relative position of men and subjects there appears in the Calendars from 1896 a classification of subjects and instructions from which this is taken.

Subject	Instructors
Mineralogy and Geology Palaeontology Metallurgy and Assaying Mining and Ore-dressing Milling German.	A. P. Coleman, M.A. Ph.D., Professor. G. R. Mickle, B.A., Lecturer. * * * Demonstrator.

The calendar for the session 1891-92 states that a lecturer in Mining Engineering was to be appointed before October 1, 1891. Apparently this idea was dropped for the time and A. P. Coleman, M.A., Ph.D., was appointed Professor of Assaying and Metallurgy on the staff of the Faculty of the School.

In 1894 Mr. G. R. Mickle was apppointed lecturer in Mining and for some years gave his time for part of the session only.

In 1901 the title of Dr. A. P. Coleman was changed to Professor of Geology. In 1902, T. L. Walker, M.A., Ph.D., was appointed Professor of Mineralogy in the Faculty of Arts of the University. In 1905 Mr. G. R. Mickle was appointed Professor of Mining. In 1907, W. A. Parks, B.A., Ph.D., was appointed Associate Professor of Geology. In 1908 Professor Mickle resigned to take up the position of Mines Assessor with the Ontario Government, and I was appointed Associate Professor of Mining, which title was changed to Professor of Mining Engineering in 1910. Mr. Geo. A. Guess was appointed Professor of Metallurgy in January, 1912.

Professor Chapman had established blowpipe and assaying laboratories at an early date and also collections of minerals and geological specimens. In 1896 a stamp-mill and ore-dressing appliances were installed, along with roasting furnaces and other metallurgical apparatus. Ten years later the fine, large Chemistry and Mining building on College Street was built. In this Professor Mickle had secured excellent accommodations for assaying laboratories, seven rooms in all, a large room for a metallurgical laboratory, and a fine separate building, seventy feet square, to accommodate the machinery for the mechanical treatment of ores. This was a magnificent step forward and the very greatest credit is due to Mr. Mickle for securing it.

I have dealt with the history of the staff and with some phases of the curriculum, and have touched on the growth of the laboratories. I should like to deal at length with the history of the time table and the subdivision of the work of the session among the different subjects.

This is a matter of very serious import. The most difficult result to achieve and at the same time the most important, is a proper balance of subjects. In the School this phase of the problem has been considered paramount. There have been many optional courses, but each course has been carefully balanced in its entirety by those in control. The student can take his choice of courses but he cannot take his choice of subjects. The engineer must be essentially a man of balanced education. This can very easily be understood when we consider what the effect would be if the subject

of mathematics were allowed to run to extremes, if the academic mathematics were developed, not to the exclusion of the practical applications, but to such an extent as to destroy the rational perspective. A true perspective is probably of more importance to the young engineer than the inclusion or exclusion of some valuable practical subject. I believe that the great strength of the School has been in the balance attained in its Engineering courses, more particularly in Civil Engineering. The course in Mining Engineering seems to have been somewhat out of the fold and to have travelled by itself, and there has not been preserved to it the balance that obtains in the other courses. The Calendar of 1908-09 gives the course in Mining Engineering as follows:

Subjects for Instruction

I. Year

Lecture Courses

Algebra	Descriptive Geometry	Dynamics
Plane Trigonometry	Surveying	Elementary Chemistry
Analytical Geometry	Statics	Elementary Mineralogy

Laboratory Courses

Drawing Surveying	Practical Chemistry	Determinative Mineralogy

II. Year

Lecture Courses

Calculus	Dynamics of Rotation	Optics
Spherical Trigonometry	Strength of Materials	Hydrostatics
Descriptive Geometry	Engineering Chemistry	Metallurgy of Iron and Steel
Surveying	Organic Chemistry	
Lithology	Geology	

Laboratory Courses

Drawing	Photography	Practical Chemistry (Quantitative)
Surveying	Hydrostatics	Determinative Mineralogy
Optics	Practical Chemistry (Qualitative	Lithology

III. Year

Lecture Courses

Descriptive Geometry	Theory of Construction	Mining and Ore Dressing
Surveying and Levelling	Engineering Chemistry	Economic Geology
Thermodynamics	Analytical Chemistry	Dynamic and Structural Geology
Hydraulics	Metallurgy	Heat
Electricity	Ore Deposits	

Laboratory Courses

Drawing	Heat	Determinative Mineralogy
Surveying	Practical Chemistry	Crystallography
Assaying		

There was at this time no course in Metallurgical Engineering; the course in Mining Engineering was supposed to prepare for both

careers. On the face of it this looks like a well balanced course, but an analysis of the distribution of time shows as follows in the course for the diploma in Mining Engineering:

Mineralogy, including Blowpiping and Determinative Mineralogy and its allied subjects of Crystallography and Petrography	162 hrs.
Geology	100 hrs.
Metallurgy of Gold, Silver, Lead, Copper, Nickel, etc	25 hrs.
Mining and Ore-dressing	25 hrs.

These figures represent the total time given to these subjects in the complete course for the diploma.

The subjects of the fourth year, which is an optional year, leading to the degree of B.A.Sc., are—Mineralogy and Geology, Metallurgy and Assaying.

In the course of three years leading to the Diploma in the Department of Mining Engineering the total time allotted to Mining was thirteen hours against 262 allotted to Mineralogy and Geology. In the fourth year of this course there was no time allotted to Mining, Mineralogy and Geology divided the year with Metallurgy and Assaying. As a further evidence of the peculiar balance of things, the Calendar shows that in 1908-09 there were in the Departments of Mineralogy and Geology two professors and an associate professor and a lecturer, while in the Department of Mining there was only an associate professor, who was responsible also for the Metallurgy.

The Government blue book dealing with University affairs shows that for that session the appropriation for the departments of Mineralogy and Geology, including salaries, supplies and apparatus, was the sum of $18,740; and for the Department of Mining, which includes Metallurgy, the sum of $5,004.

Mineralogy is the science of minerals and Geology is the science of rocks. The basis of the mineral industry is minerals, and minerals are found in rocks. The attitude of the University of Toronto was to look to Mineralogy and Geology for that enlightenment and for that philosophy which should aid the mineral industry.

(To be continued)

REGINA ENGINEERING SOCIETY

On August 1st, the Engineering Society of Regina, held a meeting which had been postponed several weeks previous, owing to the devastation of the cyclone which visited the city on July 1st. Mr. P. Gillespie of the Department of Applied Mechanics, University of Toronto, addressed the meeting on "Re-inforced Concrete Columns." Mr. H. S. Carpenter, acting deputy Minister of Public Works for Saskatchewan, presided. A vote of thanks was moved by Mr. A. J. McPherson, Chairman of the Saskatchewan Highways Commission, and seconded by Mr. L. A. Thornton, City Commissioner for Regina.

Architectural Drawing in the University of Toronto

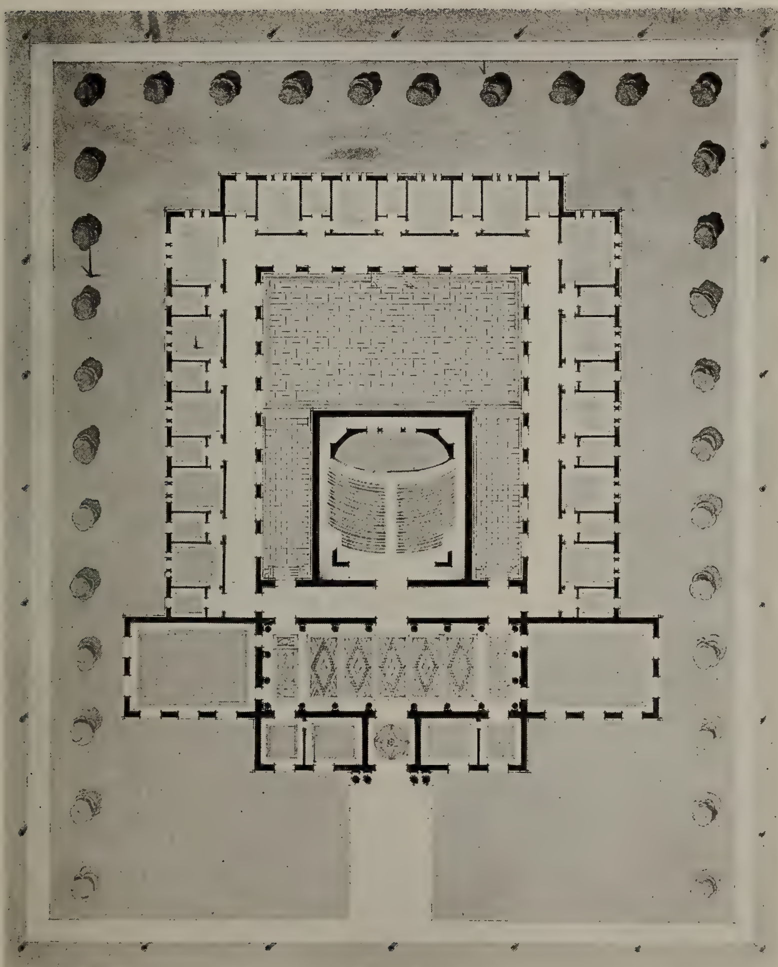
A Few Examples of Undergraduate Work During 1911-12

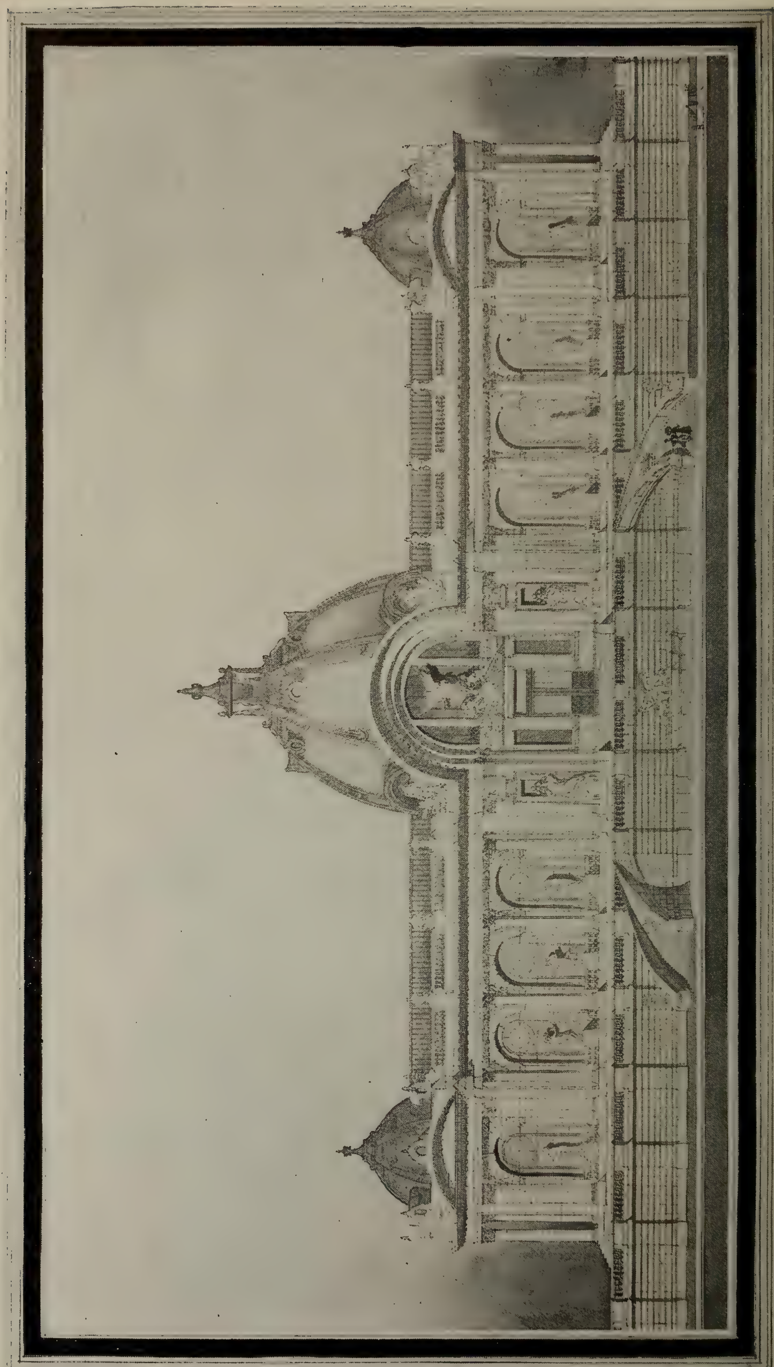
THE plate on the opposite page represents a design for a Provincial School of Music

BY

R. S. McCONNELL,

a third year student in the Department of Architecture, 1911-12



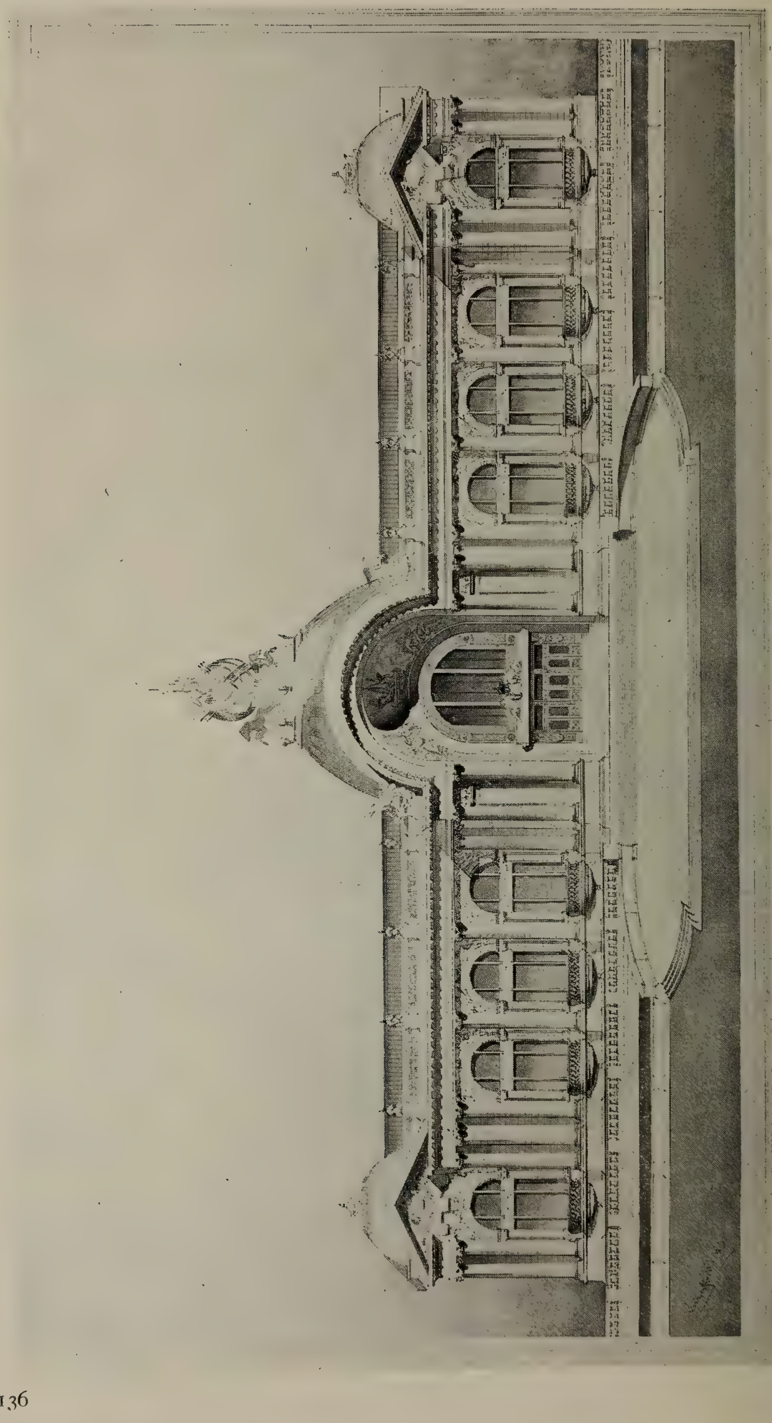


THE reproduction opposite is a representation of Le-islative Buildings for a Canadian Province

BY

J. H. CRAIG,

last year a fourth year student in Architecture, University of Toronto ; now a member of the architectural firm of Craig & Madill, Toronto,

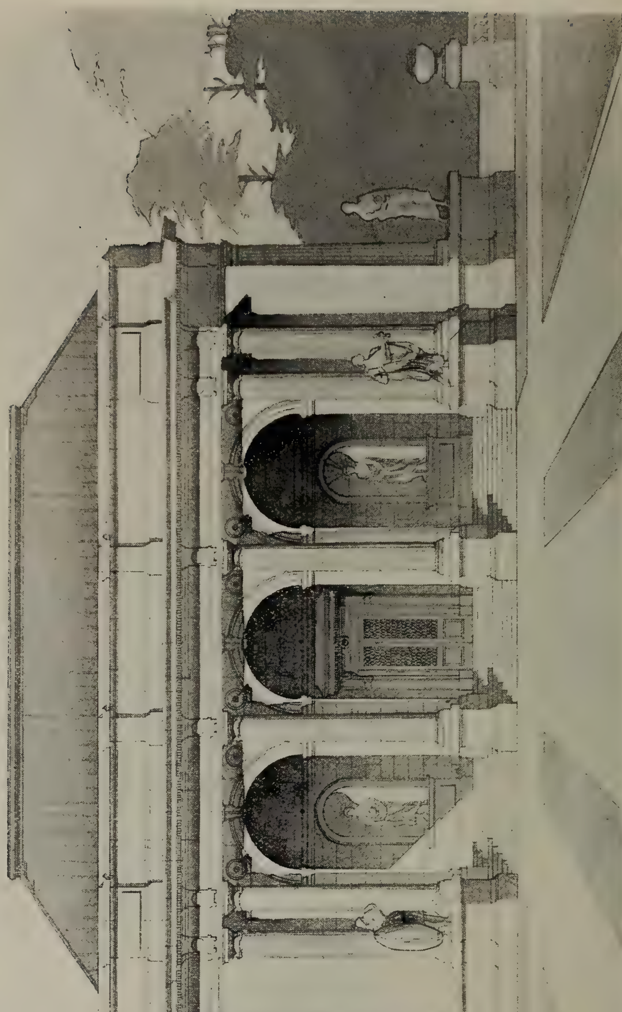


REPRESENTING a design for Parliament Buildings drawn

BY

H. H. MADILL,

a fourth year student last year in the Department of Architecture, University of Toronto.

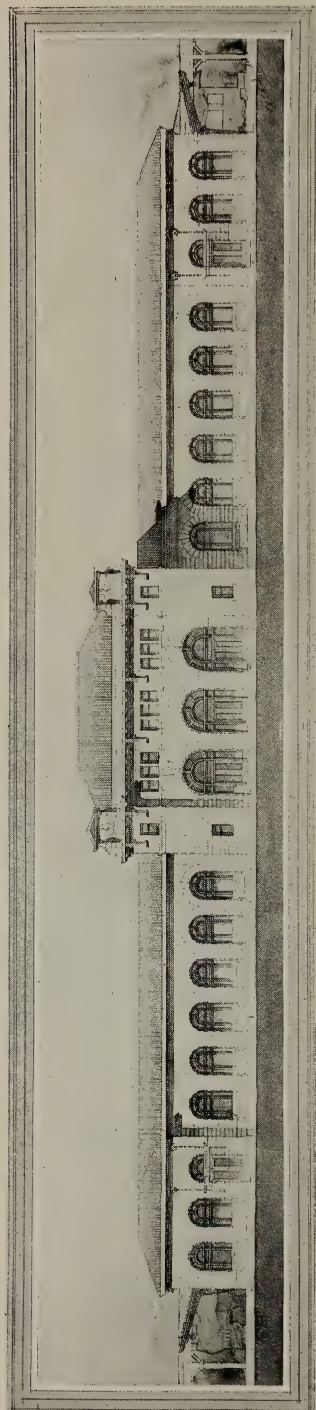


THE drawing on the opposite page was executed

BY

A. C. WILSON,

a member of the second year in Architecture, 1911-12, University of Toronto, and is a design for a Museum.

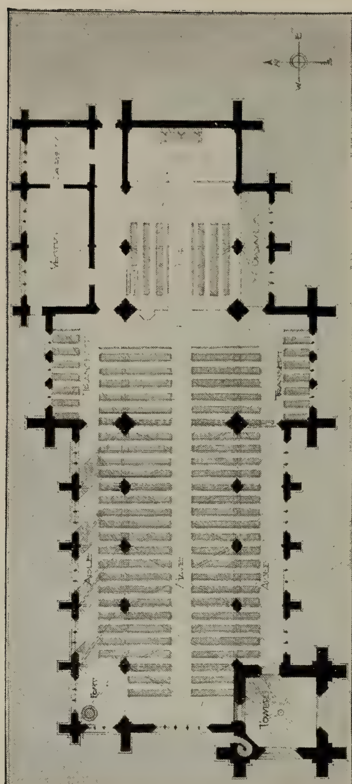


A TERMINAL Railway Station as designed

BY

H. H. MADILL

last year a student in the fourth year in Architecture, University of Toronto. Mr. Madill is now a member of the architectural firm of Craig & Madill, Toronto.



A DESIGN, in plan, for a Church

BY

L. C. M. BALDWIN

of the third year class in Architecture, University of Toronto, 1911-12.

LOCOMOTIVES—STEAM VERSUS ELECTRIC

By R. V. Macauley, B.A.Sc.

A great many of the features attending present day railroad operation are due in reality to certain characteristics of the steam locomotive. Under electric operation, sweeping changes in methods of conducting transportation are often either necessary or advisable. It is therefore necessary in arriving at intelligent conclusions regarding the advisability, or otherwise, of trunk line electrifications under different conditions, to have an intimate knowledge of the characteristics of steam and of electric power, as applied to traction work.

Steam Operation

Physical Characteristics of Steam Locomotives

All traffic on steam railroads is handled by means of steam locomotives. These locomotives, although of diverse types designed for the different service conditions, have many characteristics in common, which are mainly due to certain limitations imposed upon them. Briefly stated, the characteristics of the steam locomotive result from the fact that the locomotive must be a self-contained power unit, having its own coal and water supply, boiler and engines, mounted on trucks and moving over a track having a gauge of 4 feet 8½ inches, at various speeds up to 60, and in extreme cases to 70 and 80 miles per hour.

Locomotives use high grade bituminous coal. Coal handling plants must be located at frequent intervals along the line. The water supply is obtained from various sources, such as lakes, rivers and wells, along the route; water stations must be located at frequent intervals along the line. Where water is extremely bad, water treating plants must be used at each water station affected. To carry the coal and water supply, a "tender" must be hauled to accompany the locomotive proper.

Compact boilers, universally of the "fire-tube" type are used. High steam pressures (150-200 pds.) are employed to secure capacity; large radiation losses result, especially in cold weather. The boiler must be worked hard to get the greatest capacity, hence economy of coal suffers. Forced draft is obtained by exhausting from the engines through the stack.

Two engines must be provided—one for each side. In most cases, two simple engines are used. These engines must run non-condensing and operate with several pounds back pressure (to produce forced draft), hence steam economy is low. The engines drive the wheels by means of connecting rods to pins on the outside of the drivers, so that bearings on driver axles, which support the greater part of the locomotive weight, must be located between the driver wheels.

Operating Characteristics

The steam locomotive is essentially a constant power machine, this power being determined by the boiler capacity. The loco-

motive is capable of continuous operation at any speed up to the maximum, but the maximum speed in a given case depends both upon the length of the train and the grade of the track. It automatically slows down when ascending a grade, so that actual horse power developed does not vary greatly at different speeds. Otherwise expressed, a steam locomotive can exert its maximum draw bar pull at starting and at very low speeds, but as the speed is increased, the draw bar pull must be decreased.

The capacity that can be obtained in a single locomotive is limited for various reasons, and capacity beyond this practicable limit is obtained by double heading or by the use of Mallet articulated compounds—the latter being used almost exclusively for low speed, heavy grade service and short hauls.

Operating conditions require that a steam locomotive be "fired-up" (an operation requiring from 500 to 1600 lbs. of coal depending upon size of locomotive); kept standing a variable time at full pressure awaiting orders or train; then the "run" is made; after which the locomotive is sent to the round house where fire is drawn, hot water blown off, and tubes cleaned for the next run. This cycle of operations is manifestly hard on the coal pile, besides requiring much idle time, and labor.

Effect of Locomotive on Track and Bridges

Steam locomotives are destructive to track mainly for the two reasons following: First, because there are heavy reciprocating masses, connecting rods, and crank which can be balanced by a counterweight at only one speed and somewhat imperfectly at that. At other speeds there is an unbalanced centrifugal force which has a tendency first to raise the wheel from the rail and then to hammer it down upon the rail. This action is known as "track pounding." Second, because the pressures of many tons acting alternately on the pistons of the respective cylinders, which are widely spaced, and thus give great leverage, result in "nosing" from side to side. Nosing of engines is a most serious characteristic as it results in rail loosening and spreading. The above two effects are of interest, not only in track maintenance and safety, but also in bridge design and safety. They also produce destructive strains in the frame of the locomotive itself.

The seriousness of this aspect of steam locomotive operation is emphasized by the report of 20 broken rails after a single trip (several years ago) of the Pennsylvania's "18 hour limited," New York to Chicago—this run being over a high class track and roadbed.

Steam locomotives, by reason of their unfavorable operating conditions, some of which have been referred to, and by reason of the severe strains set up in the locomotive frame, by boiler strains, nosing, bumping, etc., require numerous repairs and renewals of an expensive nature. The maintenance of steam locomotives demands extensive round houses with their complement of labor. The maintenance and repair cost of steam locomotives constitutes one of the chief items of expense in railroad operation.

Electric Operation

With electric traction there are two different methods of conducting transportation service. First, by the use of electric locomotives in a similar manner to that in which steam locomotives are used, that is, in hauling trains of freight or passenger cars. Second, by the use of motor cars in "multiple-unit" trains.

Most of the characteristics of electric locomotives and motor cars result from the methods employed for receiving power electrically and developing mechanical power.

Electric locomotives and cars (in three systems considered) receive their power through a contact system of electrical conductors from a central power station. The different systems of "working conductors," and the different kinds of motors used were briefly described in my article entitled "Electric Traction and its Progress," in the July number of Applied Science. Electric motors have a rotating element which develops mechanical power. The torque exerted by this rotating element is uniform (single phase motor has pulsating torque—but this is not serious at frequencies above, say, 15 cycles).

Motor Control

The motors require some system of control for varying the speed; the different methods of control were treated in the article mentioned above. One peculiar possibility with electric control is the "multiple-unit" system of operation. By this system it is possible to operate any number of motor units in "multiple" from the head of the train and in such a manner that each motor takes its proportionate share of the total load. This system is applied both to locomotives and to motor cars.

As applied to electric locomotives, the multiple unit system makes possible the concentration of very great tractive power, and makes it practicable by giving each locomotive an equal division of load, while requiring only one operating crew. As applied to motor car trains, this system permits of the application of great power to the axles throughout the train, and thus permits of the utilization of any desired train weight (up to the limit--when every axle is equipped) for driving adhesion at the rails; it is obvious that this makes possible very high rates of acceleration and consequently high schedule speeds in a service where stops are frequent—such a service as is required in suburban and other local passenger operation.

Operating Characteristics

Electric locomotives and cars draw their power from a large power station whose capacity is very great. The motors on the trains are able to stand very great overloads for short periods, while the continuous power output which it is permissible to develop is determined by the heating of the motor and in some cases by the commutation.

As before stated there are two methods of conducting service, namely, by locomotive trains and by multiple unit motor car trains. Each method possesses advantages for different classes of service. In general, electric traction methods tend in America to the use of multiple unit trains, for all short runs and local services. Electric locomotives are employed only where necessary, that is, for long express runs where cars must go beyond the electric zone, for special freight service such as heavy grade pusher and tunnel work and for terminal shunting.

Effect of Locomotives and Cars on Track, Road and Bridges

When the first development of electric locomotives began, it was thought that, "the characteristics of rotary motion and uniform torque possessed by the electric motor made its application to a locomotive a simple matter, and removed one of the chief defects of the steam locomotive, namely, the unbalanced reciprocating weights and unsymmetrical turning effort, which were held to be destructive to track."

Experience soon showed however, that the electric locomotives as designed were very hard on track, particularly at curves. There were two main reasons: first, excessive non-spring-borne (or "dead") weight per axle; second, low centre of gravity.

Since the large railroad companies have adopted electric locomotives, it is a notable fact that there has been a decided improvement in electric locomotive design.

A great number of tests have been made (notably by the Pennsylvania Railroad Company) and logical conclusions have been arrived at, which in brief, are thus stated by Gibbs: "It was found that all types of locomotives (referring to electric—R.V.M.) were practically steady at speeds under 40 miles per hour, but that above this speed, marked differences appeared, that the steadiest riding machines were those with high centre of gravity and with long and unsymmetrical wheel base. In other words, that the nearer steam locomotive design is approached in wheel arrangement, distribution of weight, height of centre of gravity and ratio of spring-borne to under-spring weight, the less the side pressures registered on the rail head."[1] Modern locomotive design is such that the cost for maintenance of way and structures is much less than with earlier designs and further improvement is hoped for.

Locomotive Repairs and Maintenance

It has been generally recognized that repair and maintenance cost of electric locomotives should be low; the main reasons being:— (1) Motive power equipment is of simple construction and moving parts are few, hence repairs are few; (2) Weight of locomotives is small per horse power, (3) On account of simplicity of construction, efficient inspection is facilitated; (4) Reliability of electric locomo-

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1 "Report No. 2. On the Question of Electric Traction." By George Gibbs. Bulletin of International Railway Congress, Jan., 1910. Page 251.

tives is high, so that few spare units are necessary; (5) Electric locomotives are capable of almost continuous operation, for long intervals hence the minimum number of locomotives to handle the traffic are required.

Economics of Electrification

In discussing the general economic aspect of electrification as applied to trunk line railroads, it must be borne in mind that railroads are built and operated for the express purpose of making profits, or a return on investment over and above the cost of operation and fixed charges. (Possible exceptions to this rule are government roads and private industrial railways). Consequently, arguments favoring electrification must be presented to the practical railroad man in the form of "dollars and cents"; and this is sometimes a most difficult thing to do. However, any specific electrification problem is generally sufficiently susceptible of analysis as to allow the engineer to state within reasonable limits what return should be realized from the adoption of electric traction.

It should be noted that in some instances (notably the New York Central and Hudson River Railroad tunnels at New York City) the law has intervened and made compulsory the adoption of electric traction for certain limited service. In such cases it becomes merely a question of, "Which is the best system for present service and future requirements?" and not, "Is electric operation, from a financial standpoint, preferable to steam operation, for a given division or divisions?"

Electrification, like any other extensive engineering work, involves the investment of a large amount of money, against which there are always "fixed charges," consisting of interest, sinking fund, etc., and such investment is not justifiable, unless an increase in net receipts can be secured which is more than sufficient to pay interest on the extra capital involved.

There are two ways in which an increase of net receipts can be brought about, namely, by decreasing the working expenses for the same service, by so modifying the service as to bring in a greater revenue, or by a combination of these.

There follows a brief discussion of the more important advantages claimed for electrification on heavy railroads. It will be noted that some of these advantages, which might be termed physical advantages (such for example, as increased safety) are extremely hard to capitalize, and their consideration might be more a matter of policy and broad judgment than a simple case of financial advantage.

Capacity

Capacity is certainly among the most important advantages which may be secured by electrification. It has been said that the keynote of electrification is capacity. By approaching the problem from this standpoint only, can full benefits be obtained.

In truck line service, capacity is desirable in the motive power, in the track and in the terminals.

With electric traction it is a simple matter to secure capacity of motive power, either in single locomotive units or in motor cars. In the case of electric locomotives, great power capacity can be concentrated in a single locomotive, also the multiple unit system of operation allows of two or more locomotives being coupled together and operated in exactly the same manner as a single locomotive; the advantages of having the train operated by a single crew in the front locomotive are obvious. In the case of motor car trains, it is possible, by equipping all axles to get a very great equivalent draw-bar pull, and the high rates of acceleration used in multiple unit motor car train operation are thus made practicable.

Capacity of locomotives is a very important point, especially in heavy freight service in general and in heavy grade work in particular; the modern tendency being towards the use of the heaviest trains practicable (heavy trunk lines run freight trains of 2000 tons to 3500 tons and as high as 4500 tons).

As stated before, great capacity of steam motive power can only be obtained by either double heading steam locomotives or by using Mallet articulated compound engines, so ably described by Mr. F. H. Moody in the March issue of this journal. The former method means doubling of locomotive crew, and unsatisfactory operation of locomotives—this being accomplished by two independent engine crews. The latter method has found extensive employment for heavy grade service but its application to long haul service is not at all extensive with the present state of the art.

Another phase of locomotive capacity besides horse power and one that can be greatly increased through electrification, is that represented by the "number of miles per locomotive per month." The electric locomotive is capable of almost continuous service at full rated capacity, whereas the steam locomotive spends a very considerable part of its time in repair shop and round house. In this connection, an analysis, made by the committee of the American Railway Master Mechanics' Association on time service of steam locomotives, on a large trunk line covering a three months' period, is given as showing the low mileage accomplished by the average steam locomotive. The test brought out the following facts:—

1. The steam locomotive is actually hauling trains only 28% of the time—making 3000 miles per month, or 100 miles per day.

2. The mechanical department is responsible for 22% of the time.

3. During 50% of the time, the locomotive is under steam, with crew and ready to go—this is the time spent on side-tracks, at terminal yards and awaiting orders.[1]

The electric locomotive can make greater mileage than its steam competitor for several reasons, namely:—

1. Greater average speed is obtained.

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1 "The Electrification of Trunk Lines." By Mr. L. R. Pomeroy. Proceedings Institution of Mechanical Engineers. July, 1910. Page 1202.

2. Less time in repair shops.
3. Roundhouse operations almost eliminated.
4. On account of greater reliability, superior conditions of operation are possible, thus the idle time spent on sidings, in yards, and awaiting orders is cut down, though by no means eliminated.

Capacity of tracks and terminals is also a most important advantage secured by electrification. In cases where, with steam operation, the tracks are congested and it would be necessary to add more trackage, it is often possible by electrification to so far increase the capacity of the existing trackage as to make unnecessary such expensive improvements as grade revision and changes in trackage and right of way. In special cases—for example, large cities, tunnels, mountain grades, etc., it is possible that the increase of trackage capacity incident to electrification, by making double tracking, or right of way changes unnecessary, would be the controlling factor in effecting a decision as to the advisability of electrifying.

The increase of passenger terminal capacity by electrification is a matter of common knowledge. It has been demonstrated in actual service that the capacity can be about doubled.

Increase of capacity of freight terminal yards can also be effected by electrification, though in this case it is not so marked as in the case of passenger terminals.

Flexibility and Simplicity

Multiple unit arrangement of locomotives and of motor cars provides a most flexible and economical system of operation. Electric locomotives and motor car trains can be operated equally well in either direction, and consequently switching operations are greatly decreased and turntables are eliminated. The mechanism of an electric locomotive is manifestly much simpler than that of a steam locomotive and advantages of simplicity are obvious.

It may be objected that the multiple unit control systems are far from the acme of simplicity. This is true of both the general systems in use. These systems being respectively: The Sprague-General Electric, which is a straight electric control system, and the Westinghouse Electro-pneumatic system, which employs an electric control circuit to govern the valves which admit compressed air to the devices operating the motor circuit switches. In spite of their apparent complications, both systems have stood the test of severe service with remarkably good results. In actual operation, both systems have been found extremely reliable.

It has been demonstrated by several years of operation that electric trains are safer and more reliable than steam trains. In view of statements sometimes made regarding reliability of electric trains, the following figure concerning recent operation on the one-time much criticized New York, New Haven and Hartford Railroad, is conclusive. A train having a delay rate equal to the average delay rate of all trains operating on the electrified divisions would go from New York City to San Francisco and back eleven times with only

three minutes delay. Such a figure is beyond the dreams of any steam operating engineer.

The familiar "weather ratings" applied to steam locomotives disappear from the horizon of electric traction; wind and snow and cold are more pleasant than summer zephyrs to the electric locomotive. To keep cool is its ambition.

Traffic Increase

Beyond doubt, passenger traffic can be largely increased by electrifying, due to inherent advantages of electric trains and also to the fact that superior operation becomes possible and practicable with electric motive power, especially in the matter of speed and frequency of trains. The greatest increase of passenger traffic is in connection with local runs which are made by light motor car trains. Since, as before pointed out, these trains are able to accelerate to full speed in a very short time and are also able to make very quick stops, a great increase in schedule speed over that obtainable with steam trains, results in a service which requires frequent stops. Since heavy locomotives are eliminated and train make-up is most flexible, it is possible to run this class of train over the system at short intervals. Increase of schedule speed and increase of frequency of trains have the effect of greatly augmenting the traffic from that class of patrons known as "commuters," and since most electrifications are and will be in future in densely populated parts of the country this class of traffic is deserving of large consideration.

It is reasonable to expect some increase of freight traffic due to the general recognition of superior service by electric traction—particularly as regards safety and reliability. In some cases a great increase of freight traffic can be effected through the electrification of terminals, and branch lines, which are the feeders for the main lines.

The traffic fostering effects of a high class local electric service, both freight and passenger, have been demonstrated in no uncertain way by the great electric interurban systems which in many cases directly parallel great trunk lines and are a source of great financial loss to those roads as well as being a monument to their lost opportunities. By electrifying certain divisions, much of this traffic can be regained and further traffic developed by the trunk lines.

Coal and Water Saving

Steam locomotives at their best, are necessarily much less efficient than large central power stations, and the contention that electrification would result in great savings in coal has been borne out in practice. Money is saved by using less coal and cheaper coal than is permissible on locomotives. Considering average heavy trunk line conditions, it has been found that to produce the same ton-miles by electric power as by steam power in passenger service requires very nearly 50% less weight of coal. For switching work the electric locomotive requires only 33% as much coal as the steam locomotive. Stillwell and Putnam estimated that if all the railroads in the United States were to electrify, the total cost (not including

fixed charges) of energy for traction, for the operation of auxiliaries, and for the supply of light and heat to passenger trains, would closely approximate 50.5% of the cost of fuel for steam locomotive service. Several years of extensive operation seems to indicate that this figure is approximately correct; being perhaps a trifle too low on account of the tendency to increase speeds under electric operation.

The cost of water supply at innumerable points along the lines is entirely saved. Also delays due to the taking of water are obviated. With electric operation water is required at the central stations only, and its cost is very small, and in any case, would be included in the cost of power.

In connection with the coal and water saving, it should be noted that with electric traction, the tender is eliminated and thereby a source of expense and non-revenue train weight.

Maintenance of Way and Structures

Included under this item is a large number of factors which are subject to great variation. Due to the absence of smoke and cinders the maintenance cost of structures along the road is greatly decreased. As regards the cost of maintenance of way, it is difficult to make accurate statements, since this item depends to such a large extent on character of service and character of equipment. It was formerly thought that great economies would be effected in this department, but such has not been the case up to the present. Locomotive and motor truck design is progressing very rapidly, but at the present time it may be said that for heavy trunk lines with a mixed service, the maintenance of way cost will be as large or larger for electric as for steam operation. When the maintenance cost of the contact system is added, it may safely be said that the cost of maintenance of way and structures will be considerably greater for electric than for steam operation.

Maintenance of Equipment

The cost of maintaining equipment is one of the large expense items of steam railroads. The three largest sub-items are the repairs and renewals to locomotives, freight cars, and passenger cars respectively.

The maintenance cost of electric locomotives is much less than that of steam locomotives, due largely to the fact that electric locomotives are very simple in comparison to steam locomotives and are not so severely handicapped by reason of their operating characteristics. As the capacity of the locomotive increases, the ratio in favor of the electric locomotive becomes greater and greater, on account of the extremely heavy maintenance cost of large steam locomotives. Where Mallets are used it has been found that the cost of maintenance is about 23c. per locomotive mile, and that they are out of service about 25% of the time. The maintenance cost of Consolidation type locomotives is well known to be from 7c. to 10c. per locomotive mile. The best available data points to a mainten-

ance cost of 3c. to 8c. per locomotive mile for heavy electric locomotives. Just here it is pertinent to remark that repair costs of locomotives, when electric and steam operation are compared at least, would be more properly stated in terms of cents per ton-mile than in cents per locomotive mile; this is evident when it is considered that ton-miles, and not locomotive-miles, are the revenue producers. Also to make a complete comparison between steam and electric operation, total costs should be given and not unit costs—the reason of course, being that one steam locomotive is not the equivalent of one electric locomotive in terms of ton-miles per month. When the matter is considered in this light the ratio in favor of electric traction appears in its correct form. After long study of mixed freight and passenger service under heavy trunk line conditions, Murray places the ratio of steam locomotive repairs to electric locomotive repairs as three to one.[1] In view of previous statements and references this figure will appear reasonable.

In electric service where locomotives are used, passenger cars have a lower maintenance cost than under steam operation, chiefly on account of the absence of smoke and cinders, also on account of somewhat smoother operation.

Where motor cars are used it is difficult to find a "common denominator" for rendering of steam and electric comparisons. This is due to the fact that motor cars combine the functions of passenger cars and locomotives on steam lines, but in general, they give a considerably different service. Operating cost of motor cars is generally given in cents per car mile and maintenance of motor car is a sub-item of this. For any definite electrification problem where it is proposed to change from steam service to a multiple unit motor car train service, data is obtainable such that cost of operation can be determined; but it seems impracticable to compare maintenance of equipment per car mile for multiple unit service to any analogous item for steam service. In other words, the whole service must be considered, both the costs per car-mile and the possible revenue per car-mile and the total car-miles which will be required. Abundant evidence is at hand to show that the total operating cost (not including fixed charges) per car-mile in favorable multiple unit service is much less for electric than for steam operation.

With respect to freight cars, the maintenance cost might be a little less with electric operation but any difference would probably be so small as to be negligible.

With electric operation, the wages of train crews are decreased on account of less idle movements, less stand-by time, less men per ton-mile in locomotive work. Wages in other departments will in general be decreased but these items might be more readily included as integral parts of the operating expense of the departments affected.

By-products may seem an insignificant term, but it can truthfully be said that some by-products of electrification on large trunk

1 Discussion on "Electric Motor vs. Steam Locomotives." By William S. Murray. Transactions A.I.E.E. Vol. XXVI. Part I. Page 150.

lines are of considerable financial importance. Among the more important by-products, the following are obvious:--lighting and power bills for stations, sheds, shops, yards, elevators, etc., are decreased; real estate values all along the route are increased, due to the abolition of the smoke and noise nuisance; it is possible to construct double-deck freight terminals with extensive warehouses over the tracks and efficient methods of freight handling are made possible; in case of passenger terminals, land is economized due to increased capacity of a given number of tracks; in large cities, double decking of tracks is possible, also large office buildings may be erected over the terminal tracks.

In conclusion, it may be said that steam railroading to-day is largely steam-locomotive practice and that the full advantages of electrification are only reached when the whole system of operation is changed to conform to the new operating characteristics. Commenting on this aspect of electrification, McCrea of the Long Island Railroad, does not hesitate to say after six years of electrical operation, that if the road were forced to revert to steam operation, "It would be necessary to abandon much of the service which would not be possible under the restrictions of steam operation."[1]

What has been accomplished during the last 16 years, is no criterion of what could have been accomplished had the art of electrical engineering, and especially electric railway engineering been as fully developed as at present. As to the future of electrification, conditions point to the progressive adoption of electric traction first in the more favorable situations, such as tunnels, heavy grades, around dense centres of population, and then a gradual extension farther and farther out on the trunk lines as the art develops and as economy and policy dictate.

E. H. Niebel, '09, has entered the employ of the Northern Electrical Manufacturing Co. in Montreal.

J. B. Goodwin, '92, is Superintendent of the Mount Hood Railway and Power Co., at Portland, Ore.

H. P. Elliott, '96, Industrial Engineer, has changed his address in Toronto, from Manning Chambers to 36 Toronto St.

W. Mines, '93, is Chief Engineer for Hoover & Mason, Chicago

W. V. Taylor, '93, is Assistant Engineer for the Board of Highway Commissioners of Quebec.

C. R. Redfern, '09, until recently assistant superintendent of construction for P. Lyall & Sons, on the Terminal Freight Station of the C. P. R. in Toronto, has been appointed Assistant Engineer, Roadway Dept. of the City of Toronto.

1 "Notes on the Electrification of the Long Island Railroad." By J. A. McCrea. Proceedings of New York Railroad Club. March, 1911. Page 2354.

SPECIAL TRACKWORK FOR CITY ELECTRIC RAILWAYS

W. E. Turner, B.A. Sc.

In the construction of electric railways in cities, and especially in paved streets, the special track layouts constitute one of the most important items to be decided on, ordered, constructed and maintained by the engineering department. The high first cost, high maintenance, and quick depreciation of even the best layouts, make them an item of great importance to the company.

As a general rule the street railway company does not manufacture its own special work and it is not the intention of this article to deal with the manufacture of specials, but rather to present a few of the most important considerations for the engineer of the railway

Fig. 1

and at the same time to explain terms and conditions which may not be familiar to those who have not encountered much special work.

A special layout is a combination of switches, mates, frogs, crossings, and curves, arranged to make connections between different tracks. In its simplest form it is a plain ninety degree crossing of two tracks, and in its more complex phases it becomes a very intricate network of steel.

Fig. 1 shows a sample layout of average complication for a business district intersection. This particular instance is what is known as "the Brigham Young Layout," surrounding the famous statue of Brigham Young at the corner of South Temple and Main Streets in Salt Lake City. In the background may be seen the Mormon temple and tabernacle, the latter having the curved roof. This layout is on the tracks of the Utah Light and Railway Company, and the other illustrations and descriptions are drawn largely from this company's standard practice. It may be interesting to note that the Brigham Young layout lost about $13,000, complete, in place, and repaved.

In Fig. 2, showing a five-centre curve, may be found the names of the most commonly used pieces in track layouts. It will be noticed that in all cases tongue switches and mates are referred to instead of split switches, which are used entirely on steam roads, but very seldom on city electric lines. There are right and left hand switches, those shown on Fig. 2, being known as right hand because the curve turns to the right when entering it from the switch. There are also right and left hand curved frogs and crossings.

A cross-over is a connection between two parallel tracks as shown in Fig. 3. The switches and mates are the same as those shown in Fig. 2, but in this case we have straight frogs and it is not necessary to carry them in "rights" and "lefts." Right hand cross-overs are always preferable where the traffic takes the right side of the street on account of avoiding a "facing switch," that is, one in which the point of the tongue faces the approaching car. Cars must stop or run very slowly when passing a facing switch. A turnout is similar to a cross-over except that the second track ends at the turnout instead of going right through. Sometimes spring switches are convenient at turnouts (see Fig. 7). For instance, if all the traffic going south takes the turnout, and all going north takes the through track, the switch may have a spring holding the tongue in position for the turnout. It is evident that cars going north will enter the switch from the rear end and spring it out of the way as they pass.

Besides the above commonly used "specials," there is an infinite number of odd pieces, such as the frog of one curve combined with the mate of another, double frogs, etc., but such cases can only be described by individual drawings.

A type of special work frequently used is what is known as the bolted or built-up construction, in which the specials are built up of pieces of rail, planed off to fit together, bent for wings and curves, and bolted through steel bars and cast steel fillers. Practically all steam road specials are made in this way, and being the least expensive form of construction, the built-up specials are adaptable to electric roads in unpaved streets where traffic is light. They are used extensively for steam and electric crossings.

A more rigid form of construction is the cast iron body which, in the molten state unites so closely with the rail components as to form practically a solid mass. The cast body has usually the hardened renewable centre as shown in Fig. 4. Notice this type of

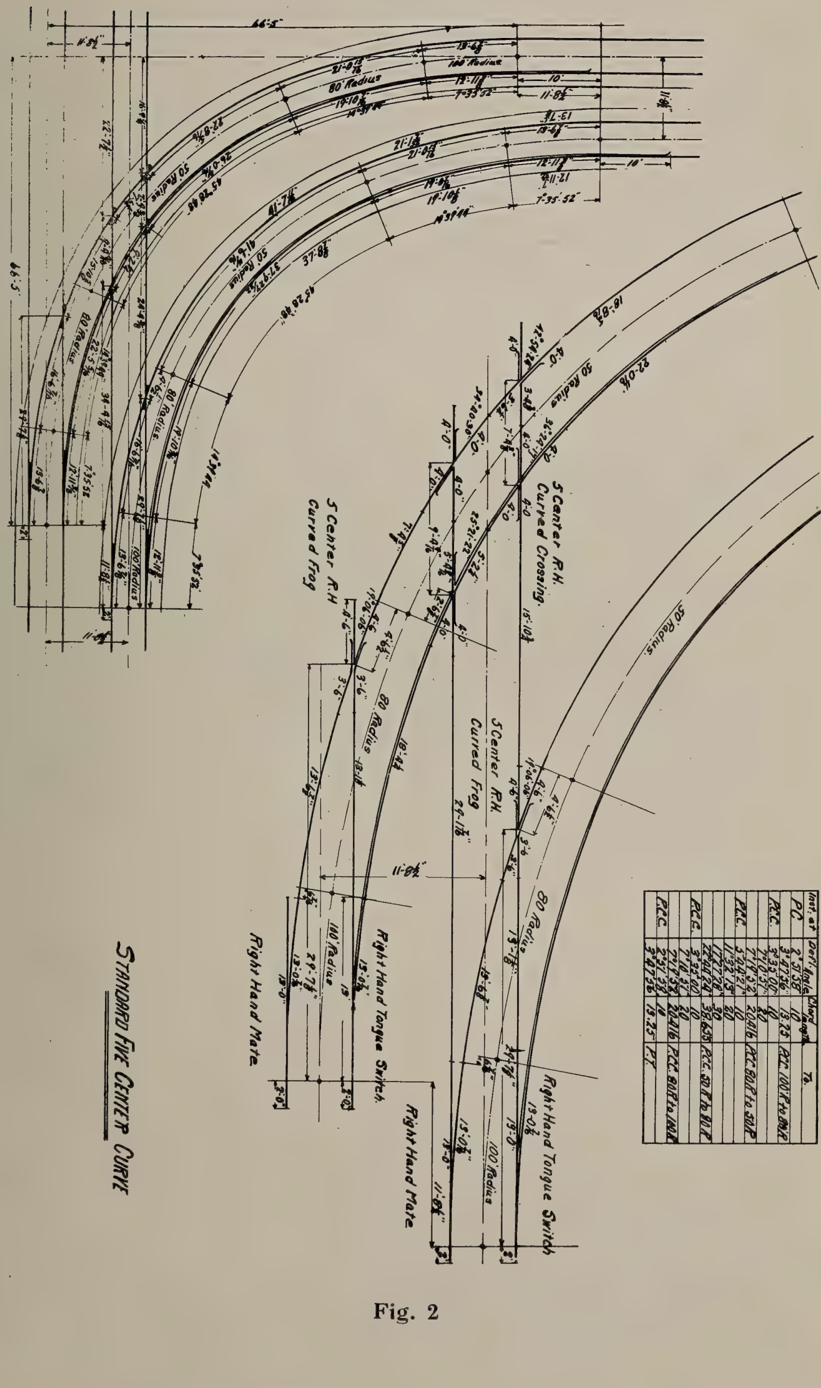

Standard Five Center Curve
5 Center R.H. Curved Crossing
5 Center R.H. Curved Frog
Right Hand Tongue Switch
Right Hand Mate
50' Radius
80' Radius
100' Radius

Fig. 2

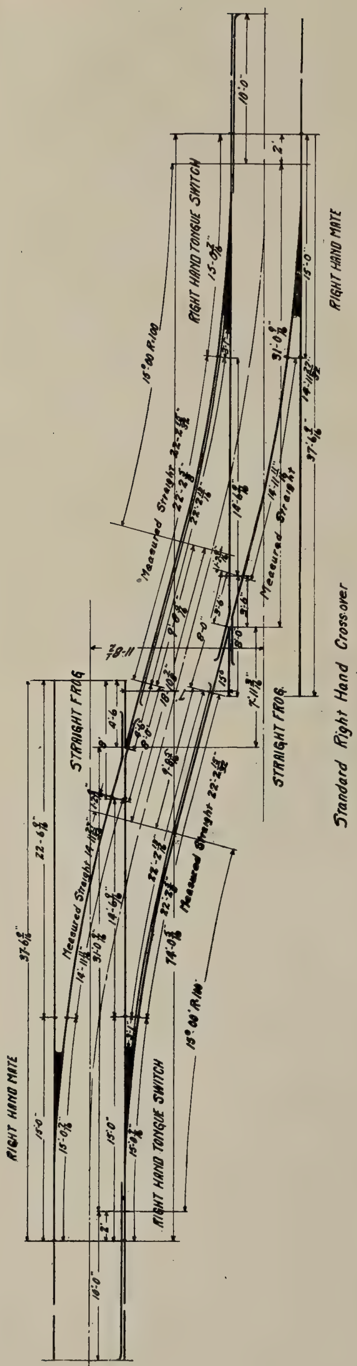


Fig. 3

construction on the Brigham Young layout, Fig. 1. The centre plate is hardened by patented and more or less secret processes, a very satisfactory combination being manganese steel, which will wear probably four times as long as ordinary rail steel.

The most substantial, and incidentally the most expensive, specials are simply solid castings with no rolled sections, but with the ends cast in the form of rolled sections to join abutting tracks. Such castings are used for very complicated pieces, and for points of heavy traffic, such as important steam road crossings in pavement, in which case the whole crossing is sometimes cast solid of hardened steel. See Fig. 5. This form is quite expensive to use.

In examining Fig. 5, it might be well to notice the wide ball on the steam road side. This takes the place of two rails, known in built-up construction as the running rail and the easer rail, and the narrow strip on the other side of the groove takes the place of the guard rail. On the electric line the easer rail is omitted.

Hardened steel rails may be obtained for use on curves where the wear is very excessive. Titanium alloy steel has been recently introduced for this purpose.

In deciding what layouts are necessary for any particular system, the first consideration is, of course, the traffic, that is, the regular car routes and special car routes for such purposes as getting in and out from barns, parking cars for resorts or circuses, fair day routes, etc. The next matter of importance is

the geographical situation—width of streets, location of curbs, distance between track centres, and possible obstructions such as poles.

At the same time it is well to investigate whether cars can pass each other on curves. This can most conveniently be done by drawing up to scale a double track curve, such as shown in Fig. 2, and drawing on a separate piece of tracing linen, to the same scale, the longest car likely to be used, with the centres of both pivot plates marked. The drawing of the car is cut out and placed on the curve. By following the centre line of the track with the two pivot plates, a clearance curve may be traced where the end of the car overhangs most.

Besides these fixed conditions to be encountered, the engineer must himself fix a condition—to make every possible piece of special

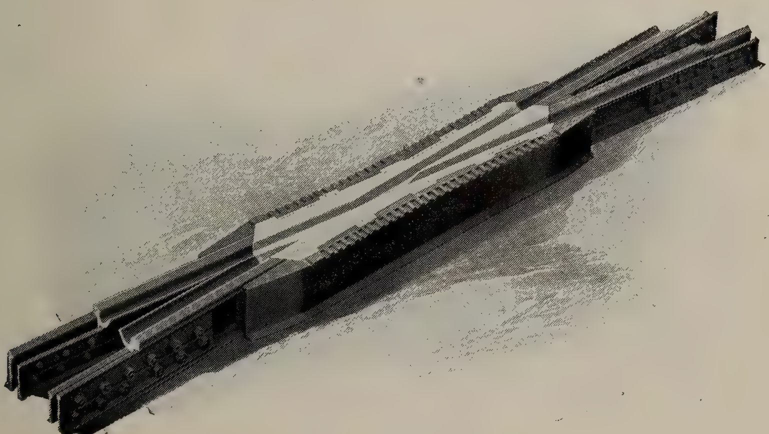


Fig. 4

work comform with certain standards. For instance, there is no reason why practically every switch and mate on the system should not be made for a 100-foot radius curve. The greatest advantage in conforming to standard pieces, is, of course, interchange ability and keeping down the stock which must be on hand for repairs, and other great advantages are the reduction in office work on ordering, keeping of records, keeping stock, in the field in laying out work, and in the shop and track departments by having pieces with which the men are familiar. Track should be standarized by using only one or two standard rail sections throughout the system, such as 65-pound A. S. C. E. rails, but where a variety of sections is used it is generally better to employ compromise joints to the special work than to order specials in odd sections.

If all double tracks are maintained at a fixed distance between centres, it will be a great step towards holding to standard special work. That will at least provide that all crossovers and turnouts

may be standardized and will insure the same advantage to curves to a very large extent.

In the design of curves the first consideration is to fit the ground and clear obstructions, the second to use standard pieces in every place possible, and the third to get the greatest available radius of curvature. As the most of the street intersections will probably be of similar design, a standard curve such as shown on Fig. 2 may be employed for all such places. In Salt Lake City, there are two standard curves in use, viz., the five-centre curve, which is shown in Fig. 2, for narrow streets, and a three-centre curve for the broader streets. The least radius in the three-centre curve is 66 feet 7 inches, and in the five centre curve, 50 feet.

A compound curve, such as is shown in Fig. 2, facilitates sharp curves on corners, permits the standard 100-foot switch and mate, and swings the car gradually from large to smaller radii. Its use is to be preferred to a plain curve. It is easily laid out in the field by

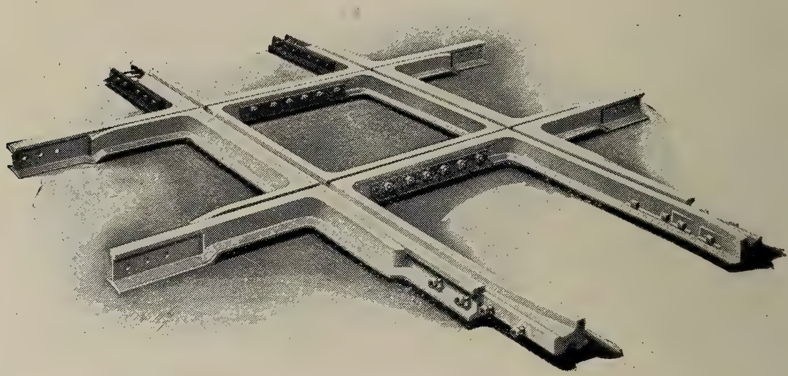


Fig. 5

reference to the table in the corner. Some of the large steel companies recommend spirals at the entrance to curves. Instead of running over a 100-foot radius and an 80-foot radius to get to the central 50-foot curve, they would start with a 100-foot radius and spiral around by an infinite series of decreasing radii to reach the 50-foot curve.

In connection with the least radius of curvature practicable for general use it is a matter impossible of accurate calculation and one upon which authorities differ. Curves of as small as 35-foot radius, and possibly less, are in use, but it is conservative practice to establish a limit at 50 feet. On a 50-foot curve the rail wear is very excessive, wheel depreciation is high, and the load on line and motors is severe.

Referring again to the necessity of standardizing all pieces, a list is given of the specials usually carried in the Utah Light and Railway Company's stock, as an illustration of the number of pieces

necessary even when all work is standardized. The 80-pound specials are high tee rail for use in the commercial district, and the 65-pound A. S. C. E. for use elsewhere. It will be noticed that frogs are not referred to by number according to steam road practice, as that system is not applicable to right and left hand curved frogs.

LIST OF SPECIALS CARRIED IN STOCK—U.L. & RY. CO.

	Frogs	Curved Crossings	
80lb R.H. switches	80lb RH. 5C	80lb R.H. 5C	80lb straight 15° frogs
80lb L.H. switches	80lb L.H. 5C	80lb L.H. 5C	80lb square crossings
80lb R.H. mates	80lb R.H. 3C	80lb R.H. 3C	
80lb R.H. mates	80lb L.H. 3C	80lb L.H. 3C	
65lb R.H. switches	65lb R.H. 5C	65lb R.H. 5C	65lb straight frogs
65lb L.H. switches	65lb L.H. 5C	65lb L.H. 5C	65lb square crossings
65lb R.H. mates	65lb R.H. 3C	65lb R.H. 3C	
65lb L.H. mates	65lb L.H. 3C	65lb L H. 3C	

Note.—R.H. and L.H. denote right and left hand, respectively.

Besides this list there are some odd pieces left from previous administrations. The above are all of the manganese centre, cast

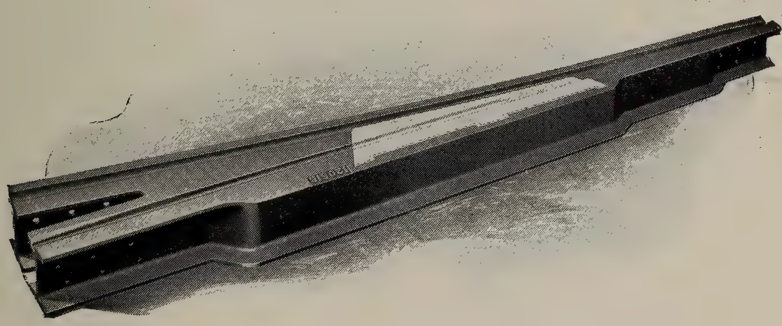


Fig. 6

body type. Steam road crossings are all special and ordered as required and are mostly of the bolted construction bought on a tonnage basis.

As the listed specials range in value from $90 to $400, they represent a considerable investment. The stock is piled in the material yard along tracks. The pieces are marked 5CL, 3CR, etc., and they are handled with a light derrick car.

Drawings should be made of all standard layouts showing distinctly the track alignment, gauges, length of wings required and in ordering the specials the above drawings may be sent to bidders without any detailed drawings of the construction, and without any rail lengths, frog angles, or other details which may be readily worked out from the data given. The steel companies always re-calculate these items and use one of their standard forms of construction on the

specials. An exception is in the bolted or built-up construction for which it is well to have a standard drawing, showing type of construction preferred, in detail but leaving out angles, radii, wings, rail sections, etc., which must be filled in for each individual case on a separate skeleton drawing.

An order for specials should cover the points to be found in the following sample order.

Sample Order

Three crossings, right hand, standard 5-centre curve, hardened steel renewable centre construction, C. I. body, for use with 7in. 80-pound rail, Lorain section No. 335 with 1in. by 5½in. bar guard plate as

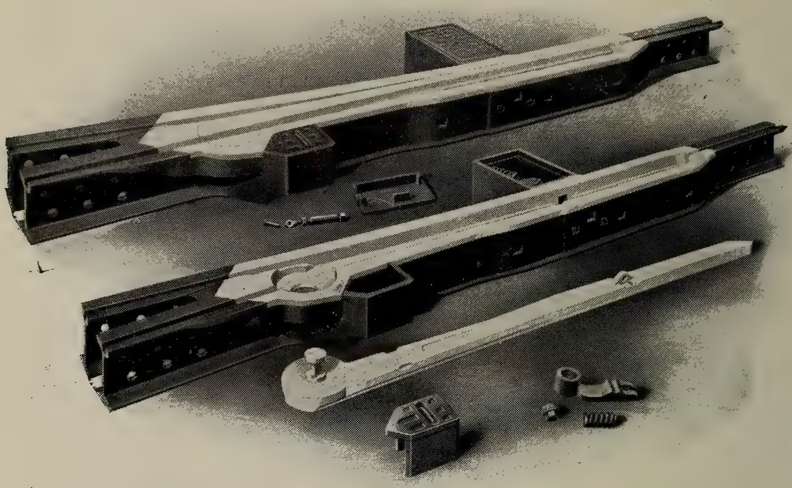


Fig. 7

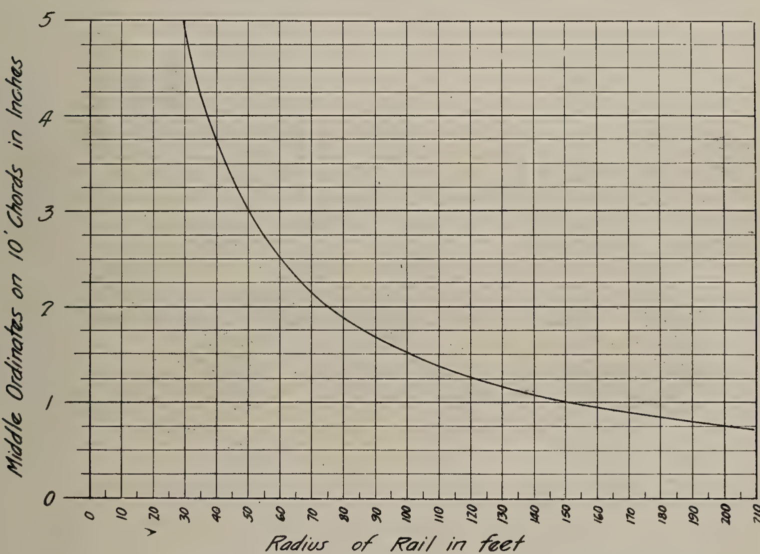
shown on drawing, No. X. Drilling for track bolt, 3-in. 6in. 1 1-8in holes; for bonds 31-32in. holes 6in. from ends, all 3¼in. above base of rail. See drawing No. Y for drilling. General layout on drawing No. Z (see Fig. 2). (It is sometimes advisable to refer to a catalogue number for type of construction.) All the drawings mentioned may be on the same or different sheets.

Whole layouts may be ordered complete from the steel companies and for complicated layouts it is a good idea to have them made up completely in the same shop, and every piece marked according to blue print. For instance, the Brigham Young layout, Fig. 1, was ordered complete and is all made of guard rail section.

It is customary to make up all simple layouts which require only the standard stock specials, in the railway company's shop. For this purpose, besides having access to a blacksmith shop, there

should be a rail bender, a fairly heavy drill press, a metal saw and saw sharpener. The track shop should be convenient to a vacant space large enough to fit together one or more layouts before taking them to the work.

Layouts are staked out with a transit at the shops and in the field (see transit notes on Fig. 2), For all curves which are not standard the following information is supplied by the engineering department for use of field and shop men; all data necessary for the exact location of track centres such as the P. C., radius and central angle of each curve, the distance between track centres and lengths of tangents. The following details more particularly for the shop men; size of rail, lengths of specials, location of switches, mates and frogs from point of curvature, lengths of each piece of rail measured straight



MIDDLE ORDINATE CURVE FOR RAIL BENDING

Fig. 8

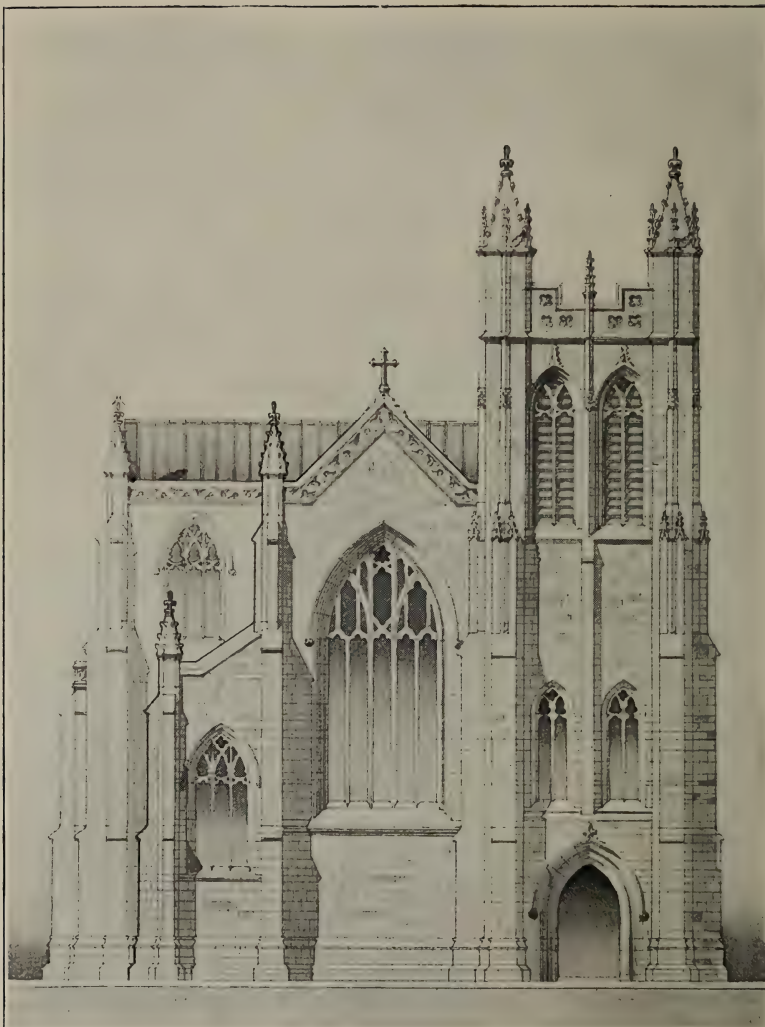
before bending and the middle ordinate of each curved rail on, for example, a 10-foot chord.

Two points might be noted in connection with this, first, that the description of curves by degree of curvature is not convenient when the radius is small, and second, that drawings or measurements, showing the location of the points of frogs or crossings, refer to the intersection of the two gauge lines and need not necessarily coincide with any actual point.

Fig. 5 is a curve showing middle ordinates on a 10-foot chord for different radii of bent rails. For very sharp curves the middle ordinate is different for the outer and inner rail. This curve is derived from the very simple formula—

Middle ordinate = $R - \sqrt{(R + \frac{1}{2}C)(R - \frac{1}{2}C)}$ where R = radius in feet of the bent rail, and C = the chord length in feet.

In the case first considered, the length of chord is 10 feet.



DESIGN FOR CHURCH

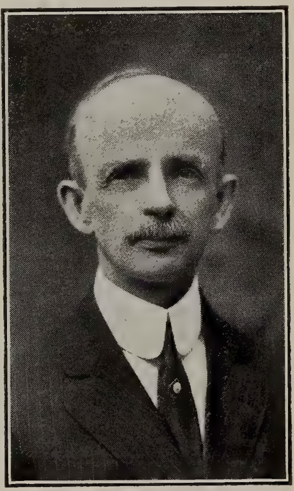
Elevational drawing by L. C. M. Baldwin. The plan is illustrated on page 140

BIOGRAPHY

The location of Mr. D. Jeffrey of the graduating class of 1882, has not been clear to us for several years. Mr. Jeffrey, when we last heard from him, was engaged in general contracting work at Windsor, Missouri, having previously carried on the same line of activity in Winnipeg, Manitoba. Mr. J. McAree, also a member of the class, was, prior to his death, eight years ago, engaged in Dominion Land Survey work in what was then known as the North West Territories. Concerning the third member of the class, Mr. J. H. Kennedy we had a good deal to write in the July issue.

D. BURNS, '83

Of the class of 1883, Mr. David Burns, whose photograph accompanies this biography, after having followed actively the profession of the engineer for over twenty years after graduation, is one of the few who reverted to academic work, his services having been acquired by the Carnegie Institute of Technology in Pittsburg.


D. Burns, '83

For a year after leaving the School, Mr. Burns was engaged on location and construction work on the Burlington and Missouri Railroad in Nebraska, and in 1885 became connected with the staff of the city of Toronto waterworks. In 1886 and for the three following years, he was a member of the teaching staff of the School of Practical Science, holding a Fellowship in Civil Engineering. He then became engaged in general survey work about the city. In 1891 Mr. Burns accepted a position in the chief engineer's office of the Pennsylvania Railroad in connection with lines west of Pittsburg. He held this position for two years, resigning to enter the office of the city engineer of Allegheny, Pa., to prepare plans for the elimination of grade crossings in that city.

Beginning in 1895, Mr. Burns spent seven years on bridge construction, first in the Keystone Bridge Works and later with the American Bridge Co. He returned to railway work in '02, and immediately put his knowledge of bridge engineering into practice on the construction of the West Side Belt Railroad, having charge of all bridges on its right of way.

When he again accepted the responsibilities of an instructor it was at the close of 1904, and the institution mentioned above, then known as the Carnegie Technical Schools, was the favored body. He carried into the organization a wealth of practical knowledge, derived from observation and application in many bracnhes

of engineering, and his ability was readily recognized, in his appointment as representative in April, 05, of the Carnegie Institute of Technology, in the erection of its buildings. He has since occupied a chair among the members of the Faculty.

Mr. Burns was granted a certificate, in April, 1890, as Land Surveyor for the Province of Ontario. He is an Associate Member of the Canadian Society of Civil Engineers.

WHAT OUR GRADUATES ARE DOING

W. O. Boswell, '11, has accepted a position with Reid, Limited of Newark, N. J., on electric furnace work.

Mackenzie Williams, '09, is connected with the firm of A. E. Ames & Co., Toronto.

W. S. Steele, '11, is on the engineering staff of the Brooklyn Rapid Transit Co. of Brooklyn, N. Y.

E. A. Greene, '11, is in the employ of the Montreal Light, Heat & Power Co.

M. Kirkwood, '11, is engaged with the Crocker-Wheeler Co., Ampere, N. J., in their D. C. engineering office.

J. H. C. Waite, '11, is at Giroux Lake, in the employ of the Drummond Mines.

W. H. Wilson, '10, and W. D. Walcott, '11, are in the engineering office of the National Bridge Co., Montreal.

W. A. O'Flynn, '11, is assistant engineer in the metallurgical laboratory of the Copper Queen Smelter, at Douglas, Arizona.

J. M. Duncan, '10, is marine engine draftsman for the Collingwood Shipbuilding Co.

Angus Smith, '94, until recently City Engineer of Victoria, is now engineer for the municipality of North Vancouver.

J. A. Morphy, '11, is in Prince Albert, Sask., where he has a contract to lay a number of sewers.

W. R. Keys, '08, is engineer for the T.C.R., on a branch line being built to Elk Lake.

A. P. Linton, '06, has been appointed assistant chief engineer for Saskatchewan, while E. W. Murray, '07, is district surveyor for the province.

J. H. Brace, '08, has for the past year been engaged in telephone engineering with the Bell Telephone Co., at Montreal. Mr. Brace has also had three years' experience in the same line of work with the New York Telephone Co.

J. V. Culbert, B.A.Sc., a member of the class in mining of '07, has been appointed mill superintendent of the recently-completed mill of the Hollinger Gold Mines, at Porcupine. This mill is the largest in Porcupine and treats the gold ore by plate amalgamation, table concentration and cyanidation of tails by the slimes process.

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EDITORIAL

A NOTEWORTHY COMPARISON

Now while the Dean is taking a few days' recreation around the northern lakes is our best chance. The oft-reiterated appreciation of his co-operation and assistance in all things that indicate strength and unity among the graduates and undergraduates of the Faculty of Applied Science and Engineering, barely escapes another voicing in every issue of this Journal. Since the days when Engineering Society itself merely inhabited the minds of the few, it has not been wanting in his support and advice. Every healthy project attendant upon school life owes in a like manner its constitution and staying powers to the steadying influence of the Dean. The Engineering Society is but an example of the force behind the institution.

Anent his great work the *Canadian Engineer* in a recent issue has this to say editorially:—"Dean Galbraith was appointed Pro-

fessor of Engineering in 1878, and for the first few years of the School's existence, he did all the engineering teaching. It is a noteworthy fact that the main features of the course, as then laid down, still control the policy of the Faculty. As Professor of Engineering, Dean Galbraith held that the practice of engineering should be learned in the field, and that the course in the School should consist of a ground work of pure mathematics, and a broad training in principles, followed by illustrations of the applications of the principles. He believes, and has consistently followed his belief in directing the trend of development, that everything should be made subservient to the idea of the application of principles. His oft repeated statement:—'We do not make engineers; we prepare them to become engineers' is worthy of record."

The editorial proceeds to comment upon a comparison of the salaries allotted to various members of the University staff, and mentions that of our Dean as being lower than a number of them. It states that "aside from his personal record this position of head of one of the most important faculties in the University demands recognition at least equivalent to the other members of the University staff." It might have stated that there were about fifteen professors whose salaries equal that of the Dean of the Faculty of Applied Science and Engineering. In other words, a Professor of such subjects as Latin, Greek, History, Geology, Bio-chemistry, or Physiology, draws a salary equal to that of the Dean, even although the latter has spent nearly thirty-five years of service in the School. It might also have been mentioned that among these and other professors there are those who conveniently can, and do, engage in various remunerative duties not pertaining to the University.

The Past Presidents' Association of the Engineering Society brought to the attention of the Board of Governors of the University the desire of a graduate body of the School to have more recognition shown the Dean, in his position as head of this Faculty. The Board of Governors, however, stated that an adjustment of the matter was impossible owing to the present financial condition of the University.

The graduates should inform themselves of the actual figures as contained in the "blue book" pertaining to University affairs—the annual report of the Board of Governors. They should thresh out the matter pro and con, and if it appears advisable, they should take up the good work of the Past President's Association, so that a request representative of the entire body of School men might be presented to the Board of Governors sometime during the coming winter.

QUALIFICATIONS OF INSPECTORS

This is concerning a recent item in the daily press about a municipal engineer, a graduate of the school, who has for some time obtained satisfactory service from younger school men as inspectors on his various classes of municipal work. A member of the town council objected to the employment of these men. He intimated that a rate-payer should be given the prefer-

ence. He even suggested that the engineer be requested to make the change on his various jobs.

Whether the complainant has personal designs for the mayorality chair or whether his request merely stated his conception of the requirements of an inspector, we will leave alone. We did not note what action the Council took. Our men are still pursuing their work as inspectors and we hope to have the pleasure of filling any vacancies that may arise on the same engineer's staff of men.

Is it possible that a man, elected to safe-guard the interests of a municipality, should hold such a flimsy opinion of the value of a good inspector on engineering work? It simmers down to a question of that alone. "School "men, with a clear conception of specification requirements and with a keen appreciation of the responsibility of their position—and generally with considerable previous experience, are the best available men for such work. This statement is borne out by the fact that the demand for them far exceeds the supply. Not that it is the most suitable line of employment for the young engineer starting out in the profession, but when it is a question of the best man for the position at the usual salary, rather than one of keeping the corporation's money in circulation among its rate-payers, the "school" man is showing himself to be the man of greatest value.

A RECORD OF OUR MEN

Of the forms sent out to all graduates during the month of May for return to this office, giving information regarding their professional work, some 367 have been received. A number of older ones are also on file, totalling responses from about one-third of the graduate body. This is not sufficient for the efficiency and usefulness aimed at. If we can establish and maintain in index form a data sheet of the professional work of every school man, susceptible to easy reference, comprehensive and reliable, it will form a volume of most valuable information for the Engineering Alumni and for the University as well. These data sheets are filled out in this office from the information the graduate sends us on the "graduate form." This is done to maintain uniformity in the series, and to properly classify forms according to the man's professional experience.

One can conceive of a dozen distinct advantages of having such a record, providing it is complete. It will facilitate in many ways the clerical work around the University pertaining to graduates. It will afford a ready means at any time of one school man locating and familiarizing himself with the work of his class mates. It will prepare in usable form a strong instrument for the graduate body to employ should the occasion arise for their mustering ideas and forces in the interests of the School. It will also be indicative of what the Institution has accomplished in its 34 years of operation.

But a representation of one-third of the graduates is not sufficient for any such purposes. The more complete our record is the

more of value it will be. Look up the circular letter sent out last May and return the enclosed "graduate form," well filled in.

EMPLOYMENT

A number of positions are open for applicants. There are several in mining, a few in electrical work, as many in architectural work, and a goodly number of vacancies in drafting offices, especially on structural steel work. If out of employment or contemplating a change, we will be pleased to supply addresses. If you have not sent us a record of your experience—let it accompany your application.

AT THE OPENING OF GILLIES' LIMIT

In the recent rush to the newly-opened 4000 acre portion of what is well known in mining circles as Gillies' Limit, a region south of the town of Cobalt, purported to be rich in mineral wealth, we note the names of a few of our "School" men standing prominently among those of the host of veteran prospectors bent on staking the best available claims.

The limit was thrown open at midnight, of August, 19th, and nearly 2000 prospectors were there to stake less than 200 claims. In less than thirty minutes the spot was again practically deserted and the excitement had subsided into an individual hustle for the recording office in Haileybury. The second man to reach the office was Angus Campbell, '10, and in a few moments, Lee Stitt, '15, appeared, to be closely followed by Bert Neilly, '07, whose special train had met with a slight delay at Cobalt. C. G. Titus, '10, and A. D. MacDonald, '11, were also in the line-up, and, as usual when School men are drawn together, the renowned Toike Oike was in evidence, according to the local press, and enlivened the long wait for the opening of the recording office door at 8.30.

WHAT OUR GRADUATES ARE DOING

Chester B. Hamilton, '06, manager of the Hamilton Gear and Machine Co., Toronto, is completing the erection of a concrete annex to his plant, doubling the capacity of his tool rooms and machine shop.

F. T. Nichol, '10, with Clarence W. Noble, Contracting Structural Engineer, is engaged at present in the Montreal office. A. E. Nourse, '07, the representative of the firm in Montreal, is seriously ill in the hospital with typhoid.

D. W. Harvey, '09, who has for some time been resident engineer on the St. Clair Avenue Civic car lines, Toronto, has recently been appointed engineer-in-charge of the civic car lines to succeed A. E. K Bunnell, '06. Mr. Bunnell has accepted a position as engineer-in-charge of construction on the Lake Erie & Northern Railway from Brantford to Galt.